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LEVEL II

ANALYSIS OF NAVAL AVIATION HEAD AND NECK INJURIES 1969-1978

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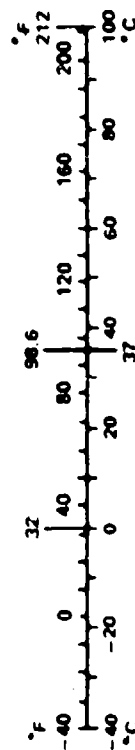
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METRIC CONVERSION FACTORS

Approximate Conversions from Metric Measures			
Symbol	When You Know	Multiply by	To Find
LENGTH			
mm	millimeters	0.04	inches
cm	centimeters	0.4	inches
m	meters	3.3	feet
m	meters	1.1	yards
km	kilometers	0.6	miles
AREA			
cm ²	square centimeters	0.16	square inches
m ²	square meters	1.2	square yards
km ²	square kilometers	0.4	square miles
ha	hectares (10,000 m ²)	2.5	acres
MASS (weight)			
g	grams	0.035	ounces
kg	kilograms	2.2	pounds
t	metric ton (1,000 kg)	1.1	short tons
VOLUME			
ml	milliliters	0.03	fluid ounces
mL	milliliters	0.06	cubic inches
L	liters	2.1	pints
L	liters	1.06	quarts
L	liters	0.26	gallons
m ³	cubic meters	35	cubic feet
m ³	cubic meters	1.3	cubic yards
TEMPERATURE (exact)			
°C	degrees Celsius	9/5 (then add 32)	degrees Fahrenheit

Approximate Conversions to Metric Measures			
Symbol	When You Know	Multiply by	To Find
LENGTH			
in	inches	2.5	centimeters
ft	feet	30	centimeters
yd	yards	0.9	meters
mi	miles	1.6	kilometers
AREA			
in ²	square inches	6.5	square centimeters
ft ²	square feet	0.09	square meters
yd ²	square yards	0.8	square meters
mi ²	square miles	2.6	square kilometers
acres	acres	0.4	hectares
MASS (weight)			
oz	ounces	28	grams
lb	pounds	0.45	kilograms
	short tons (2,000 lb)	0.9	metric ton
VOLUME			
tsp	teaspoons	5	milliliters
Tbsp	tablespoons	15	milliliters
in ³	cubic inches	16	milliliters
fl oz	fluid ounces	30	milliliters
c	cups	0.24	liters
pt	pints	0.47	liters
qt	quarts	0.95	liters
gal	gallons	3.8	liters
ft ³	cubic feet	0.03	cubic meters
yd ³	cubic yards	0.76	cubic meters
TEMPERATURE (exact)			
F	degrees Fahrenheit	5/9 (after subtracting 32)	degrees Celsius



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1.0 INTRODUCTION

Modern combat and most non-tactical aircraft of all military departments have one basic mission similarity, i.e., quick relative response and fast engagement or delivery time. With turbine engine installations this is true even for rotary-wing aircraft. Engineering design to achieve such high speeds has placed emphasis on propulsion systems, structures, and environmental systems to support operator functions at high altitudes, high speeds, all weather conditions, etc. The operator(s) must function if any manned air mission is to be undertaken and accomplished. If either fatal or survivable accidents are to be avoided, operator functions must occur in a skilled, systematic, reflexive order. Damage to the upper body region, particularly head and neck, constitutes the greatest threat to sustaining proper operator functions, and a great deal of research effort has been expended to develop protective measures to prevent upper body damage, e.g., helmets, armor, restraint, and ejection systems.

The need for high performance, and also increased armament, has resulted in decreased crashworthiness and, to some extent, decreases in operator protection. This has not been a deliberate process, but rather an acknowledged trade-off to advanced mission requirements. Devoting effort to crashworthiness in a 600-mph impact has known end points.

High performance aircraft accidents are characterized by low survival rates, usually as a result of impact forces and/or resulting fires. Many such accidents are a matter of public record, and the public instinctively seeks to know the number of fatalities. If there are survivors, this is regarded as remarkable. How much the lost aircraft costs also continues to elicit some wonderment.

The main thrust of the effort reported herein has been to identify information which will denote where further research on protection for the head and neck should be conducted.

1.1 OBJECTIVES

Navy aeromedical personnel have a historic devotion to improving survivability for all aircraft occupants, and have developed and maintained an accident reporting system which provides extensive data on skull, face, eye, neck, and cervical injuries as well as injuries to other body parts. Injury locations, causes, diagnoses, and contributing factors are computerized and readily accessible in the data bank maintained by the Naval Safety Center, Norfolk, Virginia. In addition, copies of Medical Officers Reports (MOR) are on file for analysis in either hard copy or microfilm.

Using both computer data and MOR, the objectives of this effort were to:

1. Determine directionality of injuries to the skull, face, eye, neck, and cervical vertebra, i.e., the location of the external causal element with respect to the crewman's position in the crash environment.
2. Identify data applications for further research.

2.0 METHODOLOGY

The methodology involved obtaining printouts of narrative and coded data on all Navy aircraft accidents which resulted in fatal and survivable injuries to the skull, face, eye, neck, and cervical regions.

The accident printout covered the period from January 1969 to March 1978. The following aircraft were involved during this period:

A-3	F-1	S-2
A-4	F-2	S-3
A-5		
A-6	F-4	T-1
A-7	F-8	T-2
	F-9	T-28
C-1	F-14	T-33
C-2		T-34B
C-4	H-1	T-39
C-9	H-2	
C-45	H-3	U-11
C-47	H-34	U-16
C-117	H-46	
C-118	H-53	AV-8A
C-121	H-57	
C-130		OV-10
C-131	P-2	
	P-3	

Several of the above aircraft are no longer in inventory, but all were included, initially, for type significance.

From the accident printout and on the basis of availability of autopsy results, specific MOR were identified, retrieved, and studied in the directionality determination effort. The limited scope of the program limited this effort to an analysis of 37 MOR.

To gain statistical data and inferences, printouts of the following were obtained and analyzed:

- Number of injuries to five regions of concern.
- Fatality and injury totals.
- Seating position totals.

For all aircraft models:

- Injury identification, location, cause, etc.
- Fatality and injury totals.

3.0 AIRCRAFT SUMMARIES (1969 - 1978)

This section presents summaries (by aircraft model and types) of injuries to skull, face, eye, neck, and cervical vertebra and further shows where these injuries were sustained by seating position. The seating position information is presented in two categories, cockpit and crew/passenger/unknown, which are then combined as total injuries (fatal and non-fatal). Much greater seating position detail is available from the data bank, but the importance of cockpit survivability is recognized and stressed in this study. A total seating position study was beyond the scope of the program. Also, study of the MOR revealed a few cases where cockpit personnel may fall in the unknown sub-category in catastrophic crash and burn accidents. These are rare cases, however, and not statistically significant.

Most of the model and type data presented here show the decrease in injuries which occurred as combat operations decreased in Vietnam. This difference in combat and non-combat operational environments is discussed later.

The aircraft information presented is taken from "Jane's All The World's Aircraft" (The Trade Press Association Ltd., London). Anomalies exist between Jane data and data furnished for the analysis, particularly where aircraft are classed as single-seat by Jane and other-than-cockpit seating data were furnished.

3.1 MODEL SUMMARIES

Analytical comments for the aircraft model summaries will deal with injuries dominance and contribution significance, with other comments as appropriate.

A-3: Table 1	Skull and face injuries account for more than half (14 of 24) of injuries in the data used. Cockpit injuries (10 of 14) were dominant.
A-4: Table 2	Skull and neck injuries (21 and 26, respectively, of 81) are most prevalent, and cockpit injuries account for 14 of 60 position data.
A-5: Table 3	Neck injuries account for nearly half (9 of 19) of injuries sustained, occurring in the cockpit for the most part.
A-6: Table 4	Skull and face injuries (17 of 58) were the most dominant injuries for the total 46 fatal and non-fatal injuries sustained. The cockpit experienced most of the 46 injuries (12 of 46).
A-7: Table 5	Skull injuries dominate A-7 accidents (29 of 81). Position information is suspect.
C-1: Table 6	Skull injuries account for all but one of the eight injuries for the C-1. Position information is suspect.
C-2: Table 7	One skull injury was reported for the C-2, resulting in one fatality in the non-cockpit position.
C-4: Table 8	As for the C-2, skull injuries dominate for the C-4 (3 of 4); these contributed to three fatalities. The C-4 is reported out of inventory.
C-9: Table 9	A single non-fatal eye injury was reported for the C-9.
C-45: Table 10	Two non-fatal cockpit injuries were derived from one each skull and face injuries. The C-45 is reported out of inventory.
C-47: Table 11	No fatalities are attributed to three skull and one face injuries. Most were sustained in the cockpit.
C-117: Table 12	One fatal (skull) and one non-fatal (face) injury were derived from non-cockpit positions.
C-119: Table 13	No fatalities resulted from one each face injuries in the cockpit and non-cockpit positions.

[illegible]

TABLE 2. ACCIDENT INJURY SUMMARY FOR A-4 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS			
							FATAL	NON- FATAL	COCKPIT		CREW/PSGR./UNK.	
									FATAL	NON- FATAL	FATAL	NON- FATAL
1969	5	6	5	6		22	6	11	2	4	4	7
1970	3	3		2	2	10	2	3		1	2	2
1971	3	1		3	3	10	5	4	4	3	1	1
1972	3	1		3	1	8	2	3	1	1	1	2
1973	2	2	1	1		6	2	3	2	1		2
1974	3		2	5		10	3	4	2	2	1	2
1975			1	4		5	1	4	1	3		1
1976	1	1			2	4	1	2	1	2		
1977	2	1		1	3	7	1	2	1	2		
1978	1					1	1		1			
TOTAL	23	15	9	25	11	83	24	36	15	19	9	17
COMBINED TOTALS						60	34			26		
							60					

TABLE 3. ACCIDENT INJURY SUMMARY FOR A-5 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL C-5 (5)	TOTAL A-5 (6)	TOTAL INJURIES		SEATING POSITION TOTALS			
									COWPIT		CREW/PSGR./CHRG.	
							FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL
1969		2		2		4		3		2		1
1970	1					1	1		1			
1971												
1972				1		1		1		1		
1973				1		1		1		1		
1974	2	2		5	2	11	2	2	2	2		
1975	1					1		1				1
1976												
1977												
1978												
TOTAL	4	4		9	2	19	3	8	3	6	0	2
COMBINED TOTALS						11	11		9		2	
											11	

TABLE 4. ACCIDENT INJURY SUMMARY FOR A-6 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVIC- CAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON- FATAL	FATAL	NON- FATAL	COCKPIT		CREW/PSGR./UNK.	
											FATAL	NON- FATAL	FATAL	NON- FATAL
1969	2	2	1	1	1	7	3	3	3	2				1
1970	1	1		3		5	1	3		2			1	1
1971		5		4	1	10		7		6				1
1972	11	2	2	2		17	10	5	7	1			3	4
1973	2	1		1		4	2	2	2	1				1
1974	1				1	2	1	1	1	1				
1975		3		1		4		2		2				
1976	2	1			1	4	1	1	1					1
1977			1	1		2	1	1	1					1
1978	2	1				3	1	1	1	1				
TOTAL	21	16	4	13	4	58	20	26	16	16	4	10		
COMBINED TOTALS							46		32		14		46	

TABLE 5. ACCIDENT INJURY SUMMARY FOR A-7 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SERIAL NO.	FATAL	EYE	HEAR	TOTAL CAS.	TOTAL INJURY	TOTAL ENTITIES		SEATING POSITION TOTALS				
							FATAL	NON-FATAL	COCKPIT		CREW/PSGR./UNK.		
									FATAL	NON-FATAL	FATAL	NON-FATAL	
1969	8	7	4	4	23	4	13					4	13
1970	5	1		2	10	5	4					5	4
1971	1		1	1	5	2	2	1	1			1	1
1972	3	1		1	9	4	2	1				3	2
1973	2			2	4	2	2		1			2	1
1974	1	3	1	2	8	1	5		2			1	3
1975				2	2		1		1				
1976	4				4	3				2		1	
1977	2	4	1	2	10	1	4	1	2				2
1978	3	2	1		6		4						4
TOTAL	29	18	8	16	10	81	22	37	5	7	17	30	
OVERALL TOTALS						59		12		47		59	

TABLE 6. ACCIDENT INJURY SUMMARY OF C-1 PIACRAFT (JAN. 1969 - MAR. 1978)

YEAR	SEATBELT (1)	FACE (2)	EYE (3)	NECK (4)	THROAT OR (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION: TOTALS			
									COCKPIT		CREW/PSGR./GUEST	
							FATAL	NON-FATAL	FATAL	NON-FATAL	FATAL	NON-FATAL
1969												
1970												
1971	2					2		2				2
1972												
1973	1					1		1				1
1974												
1975												
1976	3				1	4	3				3	
1977	1					1		1				1
1978												
TOTAL	7	0	0	0	1	8	3	4	0	0	3	4
GRAND TOTALS							7		0		7	
											7	

TABLE 7. ACCIDENT INJURY SUMMARY FOR C-2 AIRCRAFT (JAN. 1969 - MAR. 1973)

YEAR	BODILY (1)	FACE (2)	EYE (3)	HEAR (4)	DENTURE DNC (5)	TOTAL (1-5)	TOTAL INJURIES				SERIOUS POSITIVE TOTALS			
							FATAL	NON- FATAL	COCKPIT	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL
1969														
1970	1					1	1						1	
1971														
1972														
1973														
1974														
1975														
1976														
1977														
1978														
TOTAL	1	0	0	0	0	1	1	0	0	0	0	1	1	0
COMBINED SERIOUS TOTALS							1		0		1			

TABLE 8. ACCIDENT INJURY SUMMARY FOR C-4 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVIC- CAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS			
									COCKPIT		CREW/PSGR./GMR.	
							FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL
1969												
1970												
1971												
1972												
1973												
1974												
1975	3	1				4	3		1		2	
1976												
1977												
1978												
TOTAL	3	1	0	0	0	4	3	0	1	0	2	0
COMBINED TOTALS							3		1			
									2			
									3			

TABLE 9. ACCIDENT INJURY SUMMARY FOR C-9 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVIC- CAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS			
									COCKPIT	FATAL	NON- FATAL	CREW/PSGR./UNK.
							FATAL	NON- FATAL	FATAL	FATAL	FATAL	NON- FATAL
1969												
1970												
1971												
1972												
1973												
1974												
1975												
1976												
1977			1			1		1				1
1978												
TOTAL	0	0	1	0	0	1	0	1	0	0	0	1
COMBINED TOTALS							1		0		1	
											1	

TABLE 10. ACCIDENT INJURY SUMMARY FOR C-45 AIRCRAFT (JAN. 1969 - MAR. 1970)

YEAR	SKULL '1,	FACE '2,	EYE '3,	NECK '4,	CERVIC- CAL '5,	TOTAL '1-5,	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL
1969														
1970	1	1				2		2						
1971														
1972														
1973														
1974														
1975														
1976														
1977														
1978														
TOTAL	1	1	0	0	0	2	0	2	0	2	0	2	0	0
COMBINED TOTALS							2				2			
											2			

TABLE 11. ACCIDENT INJURY SUMMARY FOR C-47 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVIC- CAL (5)	TOTAL (1-5)	TOTAL INJURED				SEATING POSITION TOTALS			
							FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL
1969	3	1				4		3		3				
1970														
1971		1				1		1						1
1972														
1973														
1974														
1975														
1976														
1977														
1978														
TOTAL	3	2	0	0	0	5	0	4	0	3	0	1	1	
COMBINED TOTALS						4	3			1			4	

TABLE 12. ACCIDENT INJURY SUMMARY FOR C-117 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVIC- CAL (5)	TOTAL (1-5)	TOTAL INJURED		SEATING POSITION TOTALS			
									CORRPIT	OPEN/PSGP./MAY.		
							FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL
1969		1				1		1				1
1970												
1971												
1972	1					1	1				1	
1973												
1974												
1975												
1976												
1977												
1978												
TOTAL	1	1	0	0	0	2	1	1	0	0	1	1
COMBINED TOTALS							2		0		2	

TABLE 13. ACCIDENT INJURY SUMMARY FOR C-118 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SMALL (1)	FACE (2)	EYE (3)	NECK (4)	DEATH- CAUSE (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS			
							FATAL	NON- FATAL	COCKPIT	FATAL	NON- FATAL	NON- FATAL
1969												
1970		1				1		1			1	
1971												
1972												
1973		2				1		2				1
1974												
1975												
1976												
1977												
1978												
TOTAL	0	2	0	0	0	2	0	2	0	0	1	1
COMBINED TOTALS						2	2		1			
									2			

C-121: Table 14	A total of 34 injuries are reported for one catastrophic accident in 1970. Skull (21) and face (10) account for the majority (31 of 34). There were 19 fatalities; three occurred in the cockpit.
C-130: Table 15	Skull (5) and neck (4) injuries (11) were dominant for the C-130. Three fatalities occurred in the cockpit and two were in non-cockpit positions.
C-131: Table 16	No fatalities resulted from one each face and cervical injuries in the C-131; both were in non-cockpit positions.
E-1: Table 17	The E-1 is reported out of inventory. It accounted for seven injuries from 1969 to 1971. Face (4) and skull (2) injuries were most prevalent. One each fatality occurred in cockpit and non-cockpit positions.
E-2: Table 18	A consistent skull and face injury trend is shown for the E-2. They accounted for 17 of 21 injuries reported (skull 9, face 8). Of 6 fatalities, 4 occurred in the cockpit.
F-4: Table 19	The F-4 Phantom does not follow the trend indicated by most of the models studied; it continues to cause serious injuries after the combat period (1969 - 1970). Skull (37) and neck (38) injuries caused 75 of the 110 injuries reported; the face had 26. Together, they account for 91% of the total 110. The cockpit is credited with 24 of 32 fatalities; other position data are suspect.
F-8: Table 20	The F-8 skull (8) and neck (8) injuries are dominant; they account for 16 of the 26 reported injuries. Position data are suspect.
F-9: Table 21	The F-9 is reported out of inventory, but it accounted for 13 injuries, mostly skull (6) and neck (5). Of 10 total position data, 8 were fatalities.
F-14: Table 22	Only one fatality (cockpit) is reported for the F-14, obviously from skull injury (2) contribution. Neck (4) and skull (3) were primary contributors to 6 non-fatal injuries.
H-1: Table 23	The H-1 injuries of 1969 through 1971 accounted for 60 of the 84 injuries. Skull (37) and face (10) injuries dominate the entire 10-year period. Of note, no cervical injuries are reported. Cockpit (35) injuries accounted for most position data; 13 were fatalities.

PAGE 14. ACCORDANT NUMBER SUBJECT FOR C-121 AIRCRAFT (JAN. 1959 - MAR. 1978) (18661)

DATE	STILL %	TUB %	BE %	ICE %	TOTAL %	TOTAL LBS	TONG DUMPS		SEATING POSITION TOTALS					
							TONG %	TONG LBS	COOP			TOTAL LBS		
									SEATING %	SEATING LBS	SEATING %			
1950														
1951	21	19	1	2	6	34	19	4	3	1	16	3		
1952														
1953														
1954														
1955														
1956														
1957														
1958														
TOTAL	21	19	1	2	0	34	19	4	3	1	16	3	4	19
						23				23				

TABLE 15. ACCIDENT INJURY SUMMARY FOR C-130 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS			
							FATAL	NON- FATAL	COCKPIT		CREW/PSGR./UNK.	
									FATAL	NON- FATAL	FATAL	NON- FATAL
1969	3			1	2	6	4		2		2	
1970												
1971												
1972												
1973												
1974												
1975	1					1		1				1
1976												
1977	1			3		4	1	2	1			2
1978												
TOTAL	5	0	0	4	2	11	5	3	3	0	2	3
COMBINED TOTALS							8		3		5	
							8					

80507001

TABLE 16. ACCIDENT INJURY SUMMARY FOR C-131 AIRCRAFT (JAN. 1969 - MAR. 1973)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVIC- CAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON- FATAL	COCKPIT	CREW/PSGR./UNK.	FATAL	NON- FATAL	FATAL	NON- FATAL
1969														
1970														
1971														
1972														
1973														
1974														
1975		1			1	2		2						2
1976														
1977														
1978														
TOTAL	0	1	0	0	1	2	0	2	0	0	0	0	0	2
COMBINED TOTALS							2		0		2		2	
											2			

TABLE 17. ACCIDENT INJURY SUMMARY FOR E-1 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SMILE (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON- FATAL	FATAL	NON- FATAL	COKPIT		CREW/PSNR./WARR.	
											FATAL	NON- FATAL	FATAL	NON- FATAL
1969	2	2				2		1						1
1970	2	2			1	3	2		1				1	
1971		2				2		1						1
1972														
1973														
1974														
1975														
1976														
1977														
1978														
TOTAL	2	4	0	0	1	7	2	2	1	0	1	1	3	2
OVERALL TOTALS							4		1		4			

[illegible]

100/0400

TABLE 19. ACCIDENT INJURY SUMMARY FOR F-4 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SQUADRON	DATE	ETE	WRECK	DEATHS	TOTAL	TOTAL INJURIES				SERIOUS POSITION TOTALS			
							DEATHS	WRECK	DEATHS	WRECK	DEATHS	WRECK	DEATHS	WRECK
1969	3	2	3	13		21	5	15	3	11	2	4		
1970	7	7	1	8		23	5	10	1	2	4	8		
1971		2	1	2	1	6	1	5	1	2		3		
1972	7	4		1		12	6	3	5	2		1		
1973	10	5		4		17	8	5	8	4		1		
1974	1	3				4		2		1		2		
1975	2				1	3	1		1					
1976	5	2	1	8		16	5	3	4	6	1	2		
1977		2		2		4		3		3				
1978	2	1	1			4	1	2			1	2		
TOTAL	37	26	7	38	2	110	32	53	24	31	8	22		
						COMBINED TOTALS	85				55			
											30			
											85			

TABLE 20. ACCIDENT INJURY SUMMARY FOR F-8 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CEREB- RAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS		
									COCKPIT	CREW/PSGR./GND.	
							FATAL	NON- FATAL	FATAL	FATAL	NON- FATAL
1969	2	4		4	1	11	3	7		3	7
1970		1	1	2	2	6	2	2		2	2
1971	3	1		1		5		4		1	3
1972											
1973											
1974	1			1		2		1			1
1975											
1976	2					2	1	1	1	1	
1977											
1978											
TOTAL	8	6	1	8	3	26	6	15	1	2	13
COMBINED TOTALS							21		3		
									21		
									18		

TABLE 21. ACCIDENT INJURY SUMMARY FOR F-9 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON-FATAL	TOTAL	NON-FATAL	COCKPIT			NON-FATAL
											FATAL	FATAL	FATAL	FATAL
1969	5					5	3				3			
1970	1			4	1	6	5	1			4	1	1	
1971		1		1		2		1				1		
1972														
1973														
1974														
1975														
1976														
1977														
1978														
TOTAL	6	1	0	5	1	13	8	2			7	2	1	0
COMBINED TOTALS							10			9			1	
													10	

100-0008

TABLE 22. ACCIDENT INJURY SUMMARY FOR F-14 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS		
									COCKPIT	CREW/PSGR./JMK.	
							FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL
1960											
1970											
1971											
1972	2					2	1		1		
1973				1		1		1			
1974											
1975	2			2		4		2			
1976	1	2		1		4		2	1		1
1977					2	2		1			1
1978											
TOTAL	5	2	0	4	2	13	1	6	1	4	2
COMBINED TOTALS							7		5		
									7		

TABLE 23. ACCIDENT INJURY SUMMARY FOR H-1 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL C-5 (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON- FATAL	COCKPIT	CREW/PSGR./UNK.	FATAL	NON- FATAL	FATAL	NON- FATAL
1969	6	13	3	6		28	2	19	1	15	1	4		
1970	13	3	1			17	9	6	6	2	3	4		
1971	3	11	4	1		15	2	8	1	2	1	6		
1972	4	1	1			6	4	1	2	1	2			
1973	3					3	3		1		2			
1974	1	1				2		2				2		
1975				1		1		1				1		
1976	3	1				4	3		2		1			
1977	4		1	3		8		5		2		3		
1978														
TOTAL	37	30	6	11	0	84	23	42	13	22	10	20		
COMBINED TOTALS						65	35				30			
											65			

H-2: Table 24	No fatalities are reported for the H-2, and face injuries (7 of 12) are dominant.
H-3: Table 25	Skull injuries dominate for the H-3 (14 of 24), and only one cockpit fatality is reported among 18 total position data.
H-34: Table 26	The H-34 is reported out of inventory, but it accounted for 15 injuries in 1969 through 1971; the skull received 12 of these. Cockpit fatalities are high (5 of 7 total).
H-46: Table 27	Like the H-1 and H-34, injuries for the 1969 through 1971 period are high (50 of 77 total); most of these are contributed by the skull (35) and face (24). Of 53 seating positions reported, 26 were fatalities; 5 occurred in the cockpit.
H-53: Table 28	The H-53 has a consistently high injury rate over the 10-year period. Like the H-46, skull (37) and face (21) dominate the total 82 reported. The cockpit experienced 7 of the 25 fatalities.
H-57: Table 29	Two face injuries contributed to one non-fatal non-cockpit injury.
P-2: Table 30	One accident in 1969 contributed most (13 of 15) of the P-2 injuries. Of the total 15, 9 were skull and 4 were face injuries. Two cockpit fatalities are derived from the position data.
P-3: Table 31	Neck (28) and skull (12) dominate the 43 reported injuries. Only fatal injuries (13) were sustained in the cockpit, half of the total 26.
S-2: Table 32	Skull injuries dominate the data reported (12 of 25), and fatalities in the cockpit (11) prevail in the total position data of 17. Also of particular note, there was a total of 15 fatalities in the position total of 17.
S-3: Table 33	Like the S-2, skull injuries dominate the injury distribution in the data for the S-3 (4 of 6). Cockpit fatalities are high also, accounting for 3 of 5 position data.
T-1: Table 34	The T-1 is reported out of inventory, and the little data available are used only for total analysis.

TABLE 24. ACCIDENT INJURY SUMMARY FOR H-2 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS				
							FATAL	NON-FATAL	COCKPIT		CREW/PSGR./CHIK.		
									FATAL	NON-FATAL	FATAL	NON-FATAL	
1969		2				2		2					2
1970													
1971		1				1		1			1		
1972		2	2			4		4			2		2
1973					1	1		1					1
1974													
1975	1	2	1			4		2			1		1
1976													
1977													
1978													
TOTAL	1	7	3	0	1	12	0	10	0	4	4	0	6
COMBINED TOTALS						10	4			6			10

TABLE 25. ACCIDENT INJURY SUMMARY FOR H-3 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CENT- CAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS			
									COCPIOT		CREW/PSGR./UNK.	
							FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL
1969		-				1		1		1		
1970	2					2		2		1		1
1971	2	1		1	1	5		3				3
1972	1	2				3		3		2		1
1973	3					3	2		1		1	
1974				2		2		2		2		
1975	2				1	3	1	1			1	1
1976	1					1		1				1
1977	1					1		1				1
1978	2	1				3		1		1		
TOTAL	14	5	0	3	2	24	3	15	1	7	2	8
COMBINED TOTALS							18		8		10	
											18	

TABLE 26. ACCIDENT INJURY SUMMARY FOR E-34 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	MONTH	PAGE	EVS	REAR	TERT- CNC	TOTAL TIME	TOTAL INJURIES		SEATING POSITION TOTALS				
							FRONT	NON- FRONT	FRONT	NON- FRONT	FRONT	NON- FRONT	
1969	3	2		1		12	3	5		2	2	1	3
1970	3					3	3			2		1	
1971				1		1	1			1			
1972													
1973													
1974													
1975													
1976													
1977													
1978													
TOTAL	12	2	0	2	0	18	7	8		5	2	2	3
						TOTAL TIME	12		7		5		
							13						

TABLE 27. ACCIDENT INJURY SUMMARY FOR H-46 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL '1	FACE '2	EYE '3	NECK '4	THORAX- CAB '5	TOTAL INJURY '6	TOTAL INJURIES				SEATING POSITION TYPES			
							FACE	NON- FACE	NON- FACE	NON- FACE	COCKPIT	NON- FACE	NON- FACE	NON- FACE
1969	14	8	5			25	11	9	2	1	2	1	9	8
1970	3	6	1		2	14	2	6		2		2	2	4
1971	6	1		1	3	11	5	2					5	2
1972	7			1		8	5	1	2				3	1
1973		4	1	2	3	10	1	4		3		3	1	1
1974	2					2	1	1	1		1			1
1975														
1976	2	2				4	1	1					1	1
1977	1	1		1		3		3		2				1
1978														
TOTAL	35	24	5	5	8	77	26	27	5	8	5	21	19	
COMBINED TOTALS						53	13				40			
											53			

TABLE 28. ACCIDENT INJURY SUMMARY FOR H-53 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON- FATAL	COCKPIT	CREW/PSGR./UNK.	FATAL	NON- FATAL	FATAL	NON- FATAL
1969	3	2		1		6	2	3			1		1	3
1970	4	8	2			14	1	7			1			7
1971	2	1		1		4	1	3			1			3
1972	7				1	8	1	5					1	5
1973	5	5	4	2		16		10				8		2
1974	1	2		6	1	10	6	3				3	6	
1975	2			2		4	3	1			2	1	1	
1976	2					2	1				1			
1977	11	3	1	2	1	18	10	4			1	1	9	3
1978														
TOTAL	37	21	7	14	3	82	25	36			7	13	18	23
COMBINED TOTALS						61		20		41		61		

TABLE 29. ACCIDENT INJURY SUMMARY FOR H-57 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVIC- CAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON- FATAL	TOTAL	COCKPIT	FATAL	NON- FATAL	TOTAL	COPEN/PSGR./UNK.
1969														
1970														
1971														
1972														
1973														
1974														
1975		2				2		1						1
1976														
1977														
1978														
TOTAL	0	2	0	0	0	2	0	1		0	0	0	1	
COVERED TOTALS							1		0		1		1	

TABLE 30. ACCIDENT INJURY SUMMARY FOR P-2 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SERIAL (1)	FARE (2)	EYE (3)	NOSE (4)	HEAD- COLL (5)	TOTAL INJURIES (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON- FATAL	FATAL	NON- FATAL	COCKPIT	FATAL	NON- FATAL	CREW/PSGR./DECK
1969	7	4	1	1		13	5	5	2	4		3	1	
1970	1					1	1					1		
1971														
1972														
1973														
1974	1					1		1					1	
1975														
1976														
1977														
1978	9	4	1	1	0	15	6	6	2	4		4	2	
TOTAL								22		6			6	
														22

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TABLE 21. ACCIDENT ENTRY SUMMARY FOR P-3 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	START (1)	END (2)	SEE (3)	TOTAL (4)	TOTAL (5)	TOTAL ENTRIES		SEATING POSITIVE TOTALS			
						POSITIVE ENTRIES	POSITIVE ENTRIES	POSITIVE ENTRIES	POSITIVE ENTRIES	POSITIVE ENTRIES	POSITIVE ENTRIES
1969				6							
1970				6		6		4		2	
1971	2				1	1				1	
1972	1			5		5	1			5	1
1973	6		1	1	1	3	6	3		6	
1974											
1975											
1976											
1977	3			10		13	1	6		5	1
1978											
TOTAL	12	0	1	28	2	43	8	26	13	0	2
COMBINED TOTALS						34		13		21	
										34	

TABLE 32. ACCIDENT INJURY SUMMARY FOR S-2 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVIC- OCC (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS			
							FATAL	NON- FATAL	COCKPIT		CREW/PSGR./UNK.	
									FATAL	NON- FATAL	FATAL	NON- FATAL
1969	4	1		1		6	3		3			
1970	2	1		2		5	2	1	1		1	1
1971	1					1	1				1	
1972	1	2				3	1	1			1	1
1973	1			1		2	2		2			
1974	2				3	5	3		3			
1975	1					1	1				1	
1976												
1977				2		2	2		2			
1978												
TOTAL	12	4		6	3	25	15	2	11		4	2
COMBINED TOTALS							17		11		6	
											17	

TABLE 33. ACCIDENT INJURY SUMMARY FOR S-3 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CEREB- CAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON- FATAL			COCKPIT		CREW/PSGR./UNK.	
											FATAL	NON- FATAL	FATAL	NON- FATAL
1969														
1970														
1971														
1972														
1973														
1974	2					2	2				2			
1975	1			1		2	1				1			
1976														
1977	1		1			2		2						2
1978														
TOTAL	4		1	1		6	3	2			3			2
COMBINED TOTALS							5		3		5			

TABLE 34. ACCIDENT INJURY SUMMARY FOR T-1 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVIC- CAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS			
									COCKPIT		CREW/PSGR./JNK.	
							FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL
1969	1					1	1				1	
1970	1					1	1		1			
1971												
1972												
1973												
1974												
1975												
1976												
1977												
1978												
TOTAL	2	0	0	0	0	2	.2	0	1	0	1	0
COMBINED TOTALS							2		1		1	
											2	

T-2: Table 35	As seen here and as will be shown later, skull injuries dominate the data distribution for trainer aircraft, 14 of 26 for the T-2. Cockpit fatalities account for near half of the position data (8 of 17).
T-28: Table 36	Skull (11) and neck (9) account for most of the injury data (20 of 31). Cockpit fatalities are nearly half of the position data (11 of 24).
T-33: Table 37	Inventory status of the T-33 is uncertain, and the little data available are used only for total analysis.
T-34B: Table 38	Skull injuries account for 9 of 14 T-34 injury data, and cockpit fatalities dominate the position data (6 of 8).
T-39: Table 39	Skull injuries (10 of 11) and cockpit fatalities (6 of 11) dominate the T-39 data. A duplication of injury and position data occurred (1974 and 1977) which could be of interest.
U-11: Table 40	Data furnished are useful only in total analysis.
U-16: Table 41	
AV-8: Table 42	Skull (7) and neck (6) dominate the AV-8 injuries (13 of total 22). Cockpit fatalities account for half of the position data (5 of 10).
OV-10: Table 43	Skull accounts for over half the injury distribution (9 of 17). Cockpit fatalities again account for a majority of the position data (8 of 13).

3.2 TYPE SUMMARIES

The injury and position data presented for each aircraft model in Section 3.1 is summarized and discussed by type in this section, e.g., attack, trainer, helicopter, etc.

The following aircraft are not included in the type summaries because of loss from inventory:

C-4	E-1	H-34
C-45	F-9	T-1

TABLE 35. ACCIDENT INJURY SUMMARY FOR T-2 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVIC- CAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON- FATAL	TOTAL	NON- FATAL	COCKPIT	FATAL	NON- FATAL	CREW/PSGR./UNK.
1969	5	1		2	2	10	4	2				4	2	
1970	1					1		1						1
1971	1			2		3	1	1				1	1	
1972	4			2		6	1	2				1	2	
1973	1					1	1					1		
1974														
1975	1					1	1					1		
1976	1	2				3		2					1	1
1977			1			1		1						1
1978														
TOTAL	14	3	1	6	2	26	8	9				8	6	3
COMBINED TOTALS							17		14		17			
											3			

TABLE 36. ACCIDENT INJURY SUMMARY FOR T-28 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON- FATAL	FATAL	NON- FATAL	COCKPIT	FATAL	NON- FATAL	HCN- FATAL
1969	3		1	3		7	6	1	6	1				
1970	1		1		1	3	2	1	1	1		1		
1971				1		1	1		1					
1972	1	1		1		3	1	2	1	2				
1973	1			1	1	3	1	2	1	2				
1974	1	6		2		9		4		4				
1975														
1976														
1977				1		1		1		1				
1978	4					4	1	1	1	1				
TOTAL	11	7	2	9	2	31	12	12	11	12		1	0	
COMBINED TOTALS							24		23			1		
												24		

TABLE 37. ACCIDENT INJURY SUMMARY FOR T-33 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS			
									COCKPIT		CREW/PSGR./UNK.	
							FATAL	NON-FATAL	FATAL	NON-FATAL	FATAL	NON-FATAL
1960		1	1	2		4	2	1	2	1	0	0
1970												
1971												
1972												
1973												
1974												
1975												
1976												
1977												
1978												
TOTAL	0	1	1	2	0	4	2	1	2	1	0	0
COMBINED TOTALS							3		3		0	
											3	

65-15367-200

Date	Time	Lat	Long	Wind	Temp	Wind Dir	Wind Spd	Clouds	Barometer				Thermometer				Hygrometer			
									Reading		Correction		Reading		Correction		Reading		Correction	
									h	m	h	m	h	m	h	m	h	m	h	m
10/10/55	0800	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	1000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	1200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	1400	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	1600	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	1800	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	2000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	2200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	2400	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	2600	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	2800	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	3000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	3200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	3400	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	3600	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	3800	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	4000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	4200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	4400	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	4600	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	4800	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	5000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	5200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	5400	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	5600	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	5800	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	6000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	6200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	6400	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	6600	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	6800	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	7000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	7200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	7400	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	7600	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	7800	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	8000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	8200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	8400	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	8600	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	8800	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	9000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	9200	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	9400	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	9600	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	9800	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
10/10/55	10000	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	

TABLE 39. ACCIDENT INJURY SUMMARY FOR T-39 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SEVERE (1)	FADE (2)	EYE (3)	NECK (4)	TEND- ON (5)	TOTAL (1-5)	TOTAL INJURIES			SEATING POSITION TOTALS			
							FACE	NON- FACE	NON- FACE	FACE	NON- FACE	FACE	NON- FACE
1969		2				2		2					2
1970													
1971													
1972													
1973													
1974	5					5	5		3			2	
1975													
1976													
1977	5					5	5		3			2	
1978													
TOTAL	10	1	0	0	0	11	10	1	6	0	4	1	5
OVERALL TOTALS						11	11			6		11	

TABLE 40. ACCIDENT INJURY SUMMARY FOR U-11 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	SERV- CAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS			
									COCKPIT		CREW/PSGR./UNK.	
							FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL
1969												
1970												
1971	1	2				3		2				
1972												
1973												
1974												
1975												
1976												
1977												
1978												
TOTAL	1	2	0	0	0	3	0	2	0	2	0	0
GRAND TOTALS							2		2		0	
											2	

TABLE 41. ACCIDENT INJURY SUMMARY FOR U-16 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVIC- CAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON- FATAL	COCKPIT	FATAL	NON- FATAL	FATAL	NON- FATAL	CREW/PSGR./UNK.
1969														
1970														
1971														
1972														
1973	1					1		1						1
1974														
1975														
1976														
1977														
1978														
TOTAL	1	0	0	0	0	1	0	1		0	0	0	1	
COMBINED TOTALS							1		0		1		1	

TABLE 42. ACCIDENT INJURY SUMMARY FOR AV-8 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS		
									COCKPIT	NON- FATAL	NON- FATAL
							FATAL	NON- FATAL	FATAL	FATAL	FATAL
1969											
1970											
1971	2					2	1		1		
1972											
1973											
1974	3			1	1	5	2		1		1
1975	1			1	1	3	2		2		
1976		3		2		5		2		2	
1977	1	1	3	2		7	1	2	1	2	
1978											
TOTAL	7	4	3	6	2	22	6	4	5	4	1 0
						COMBINED TOTALS	10		9		
									10		

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TABLE 43. ACCIDENT INJURY SUMMARY FOR 07-10 AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVIC- DAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS			
									COCKPIT		CREW/PSSE./GRR.	
							FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL
1969	4	1		3		8	5	1	4		1	1
1970	2	1		1		4	3	1	3	1		
1971	3					3		1				1
1972			1	1		2	1	1	1	1		
1973												
1974												
1975												
1976												
1977												
1978												
TOTAL	9	2	1	5	0	17	9	4	8	2	1	2
COMBINED TOTALS							13		10		3	
											13	

The following aircraft are not treated because of insufficient information on which to base type analysis:

E-2

U-11
U-16

OV-10

3.2.1 Attack Aircraft

Attack (and fighter) mission performance requirements are characterized by high velocities at all altitudes. Take-off and landing speeds are also higher than most aircraft. Accidents involving attack aircraft are thus more apt to result in high impact forces, causing multiple severe injuries to occupants. Table 44 supports this, and shows that the skull, neck, and face receive most of the injuries (212 of 265 reported).

Of the 190 position totals, the cockpit accounts for slightly over half (97). Of these 97, 42 were fatal.

3.2.2 Cargo Aircraft

Cargo aircraft come in many sizes, and mission requirements call for considerably more than cargo or personnel transport. Propulsion systems include radial, turbo, and jet engines. In general, speed requirements for take-off, landing, and flight are much lower than attack or fighter aircraft. There is some basic similarity in overall configuration, however, and it is believed that the C-type aircraft can be considered inclusively.

Table 45 shows that skull injuries dominate for cargo aircraft (38 of 67, over half). This could be attributed to more persons not in flight system restraint; this contention is supported in the position data. Also, cockpit fatalities are low in the overall position data (6 of 50), perhaps another manifestation of the slower operational environment.

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TABLE 44. ACCIDENT INJURY SUMMARY FOR ATTACK AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON-FATAL			COCKPIT	FATAL	NON-FATAL	CREW/PSGR./UNK.
1969	15	20	11	15	1	62	13	34			5	10	8	24
1970	15	7	0	9	6	37	10	15			2	8	8	7
1971	4	6	1	8	6	25	7	13			5	10	2	3
1972	18	5	2	7	5	37	18	11			10	3	8	8
1973	7	4	1	6	2	20	7	9			5	4	2	5
1974	7	5	3	12	4	31	7	12			5	7	2	5
1975	1	3	1	7	0	12	1	8			1	6	0	2
1976	7	2	0	0	3	12	5	3			4	2	1	1
1977	4	5	2	4	4	19	3	7			3	4	0	3
1978	6	3	1	0	0	10	2	5			2	1	0	4
TOTAL	84	60	22	68	31	265	73	117			42	55	31	62
COMBINED TOTALS							190				97			
											190			

TABLE 45. ACCIDENT INJURY SUMMARY FOR CARGO AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CER/1- CAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON- FATAL	COCKPIT	CREW/PSGR./UNK.	FATAL	NON- FATAL	FATAL	NON- FATAL
1969	6	2	0	1	2	11	4	4			2	3	2	1
1970	22	11	1	2	0	36	20	5			3	2	16	3
1971	2	1	0	0	0	3	0	3			0	0	0	3
1972	1	0	0	0	0	1	1	0			0	0	1	0
1973	1	1	0	0	0	2	0	2			0	0	0	2
1974	0	0	0	0	0	0	0	0			0	0	0	0
1975	1	1	0	0	1	3	0	3			0	0	1	3
1976	3	0	0	0	1	4	3	0			0	0	3	0
1977	2	0	1	3	0	6	1	4			1	0	0	4
1978	0	0	0	0	0	0	0	0			0	0	0	0
TOTAL	38	17	2	6	4	67	29	21			6	5	23	16
COMBINED TOTALS							50		11		39		50	

3.2.3 Fighter Aircraft

Fighter aircraft have mission and performance requirements similar to attack aircraft. Injury distribution is similar also; this is shown below:

<u>Aircraft</u>	<u>Injuries</u>	<u>Percent of Injuries</u>				
		<u>Skull</u>	<u>Face</u>	<u>Eye</u>	<u>Neck</u>	<u>Cervical</u>
Attack	265	32	23	8	25	12
Fighter	149	33	23	6	33	5

Table 46 also shows an expected dominance of cockpit injuries (63 of 113), inclusive of 26 fatalities.

3.2.4 Helicopters

Helicopter accidents generally have a more pronounced vertical component than fixed wing aircraft. This consideration and the contribution of rotor blade strikes may account for the high incidences of face injuries shown in Table 47 (89 of 281 total injuries, 31%). Of the aircraft types studied, skull and face injuries for helicopters are the highest combined injuries; skull (124) and face (89) together account for 213 (75%) of 281 injuries.

Position data are as expected, reflecting (to some extent) troop-carrying missions during combat periods. The significance of the drastic increase in injuries in 1977 would be of interest.

3.2.5 Patrol Aircraft

Patrol aircraft, like cargo aircraft, have a variety of missions, and low-speed, long-range characteristics typify both types. Injury incidence is significantly different, however, as shown on the following text page:

TABLE 46. ACCIDENT INJURY SUMMARY FOR FIGHTER AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON-FATAL	FATAL	NON-FATAL	FATAL	NON-FATAL	FATAL	NON-FATAL
1969	5	6	3	17	1	32	8	22	3	11	5	11	5	11
1970	7	8	2	10	2	29	7	12	1	2	6	10	6	10
1971	3	3	1	3	1	11	1	9	1	3	0	6	0	6
1972	9	4	0	1	0	14	7	3	7	2	0	1	0	1
1973	10	3	0	5	0	18	8	6	8	5	0	1	0	1
1974	2	3	0	1	0	6	0	3	0	1	0	2	0	2
1975	4	0	0	2	1	7	1	2	1	2	0	0	0	0
1976	8	4	1	9	0	22	6	11	5	8	1	3	1	3
1977	0	2	0	2	2	6	0	4	0	3	0	1	0	1
1978	2	1	1	0	0	4	1	2	0	0	1	2	1	2
TOTAL	50	34	8	50	7	149	39	74	26	37	13	37	37	50
COMBINED TOTALS							113				63			
											113			

TABLE 47. ACCIDENT INJURY SUMMARY FOR HELICOPTERS (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS			
							FATAL	NON-FATAL	COCKPIT		CREW/PSGR./UNK.	
									FATAL	NON-FATAL	FATAL	NON-FATAL
1969	23	26	6	7	0	62	15	34	4	17	11	17
1970	22	19	4	0	2	47	12	21	7	5	5	16
1971	13	15	0	4	4	36	8	17	2	3	6	14
1972	19	5	3	1	1	29	10	14	5	5	6	9
1973	11	9	5	4	4	33	6	15	1	11	4	4
1974	4	3	0	8	1	16	7	8	1	5	6	3
1975	5	4	1	3	1	14	4	6	2	2	2	4
1976	8	3	0	0	0	11	5	2	3	0	2	2
1977	17	4	2	6	1	30	10	13	1	5	9	8
1978	2	1	0	0	0	3	0	1	0	1	0	0
TOTAL	124	89	21	33	14	281	77	131	26	54	51	77
COMBINED TOTALS							208		80		128	
											208	

<u>Aircraft</u>	<u>Total Injuries</u>	<u>Skull</u>	<u>Face</u>	<u>Eye</u>	<u>Neck</u>	<u>Cervical</u>
Cargo	67	38	17	2	6	4
Patrol	60	23	4	2	29	2

Table 48 shows the patrol aircraft data. The disproportionate number of neck injuries is of great interest, but it may be attributed to the sparseness of the patrol data (only P-2 and P-3) as compared to the 11 cargo aircraft studied.

Position data shows a very high fatality trend (32 of 46 positions). This fact coupled with the neck injuries is of great interest.

3.2.6 Search Aircraft

There are great differences in the S-2 and S-3 aircraft, e.g., propulsion, range, speed, etc., but the mission and operating environment similarity is sufficient to permit combining data. When done, as shown in Table 49, neck injuries again show some prevalence (as for patrol aircraft), but skull injuries dominate the data (16 of 31).

Also like patrol aircraft, the fatality trend is high (18 of 22 position data; 14 in cockpit).

3.2.7 Trainer Aircraft

There are many configuration differences in the trainer aircraft used as data sources for the information shown in Table 50. Training performance requirements for the aircraft vary proportionately, however, and the data combination is considered valid.

Skull (44) and neck (19) combine (63) to account for 73% of the total 86 injuries reported.

TABLE 48. ACCIDENT INJURY SUMMARY FOR PATROL AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVICAL (5)	TOTAL (1-5)	TOTAL INJURIES				SEATING POSITION TOTALS			
							FATAL	NON-FATAL	FATAL	NON-FATAL	COCKPIT		CREW/PSGR./UNK.	
											FATAL	NON-FATAL	FATAL	NON-FATAL
1969	7	4	1	7	0	19	5	5	2	4	2	4	3	1
1970	1	0	0	6	0	7	7	0	4	0	4	0	3	0
1971	2	0	0	0	1	3	1	0	0	0	0	0	1	0
1972	3	0	0	5	0	8	5	1	0	0	0	0	5	1
1973	7	0	1	1	1	10	3	7	3	0	3	0	6	1
1974	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	3	0	0	10	0	13	11	1	6	0	6	0	5	1
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	23	4	2	29	2	60	32	14	15	4	15	4	23	4
COMBINED TOTALS							46		19		27		46	

TABLE 50. ACCIDENT INJURY SUMMARY FOR TRAINER AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SPRINT '69	PAGE '70	BEE '73	VEER '74	CRASH- OUT '75	TOTAL '76	TOTAL INJURIES		SERIES POSITION TOTALS			
							FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL
1969	11	3	2	7	2	25	12	5	12	4	0	1
1970	2	1	1	0	1	5	4	3	3	2	1	1
1971	2	0	0	3	0	5	2	1	2	1	0	0
1972	3	1	0	3	0	9	3	4	3	4	0	0
1973	2	0	0	1	1	4	2	2	2	2	0	0
1974	10	5	0	2	0	18	5	4	3	4	2	0
1975	2	0	0	0	0	2	3	0	3	0	0	0
1976	1	4	0	2	0	7	1	3	1	2	0	1
1977	3	0	1	1	0	7	5	2	3	1	2	1
1978	4	0	0	0	0	4	1	1	1	1	0	0
TOTAL	44	15	4	19	4	86	38	25	33	21	5	4
COMBINED TOTALS						63	54		9			
									63			

There are no major similarities with attack and fighter aircraft data, as shown below:

Aircraft	Injuries	Percent of Injuries				
		Skull	Face	Eye	Neck	Cervical
Attack	265	32	23	8	25	12
Fighter	149	33	23	6	33	5
Trainer	86	51	17	5	22	5

Cockpit positions understandably account for most of the position data, and cockpit fatalities are also high (33 of 63 positions).

3.2.8 V/STOL Aircraft

The V/STOL information is based entirely on the AV-8A aircraft, and most of the data came from take-off and landing accidents with catastrophic impacts/ejections and burns. Thus, the dominance of skull and neck injuries shown in Table 51 can be related to a specific environment.

The cockpit fatality trend (5 of 10 total positions) also attests to the type of accident and air/ground environment.

3.3 ANALYSIS AND DISCUSSION

The injury data presented in the type summaries (Section 3.2) are shown by percentage contribution (per aircraft) in Table 52. Since there are eight aircraft types involved, there are potentially 800 percentage points. These are totalled and then divided by 8 to gain overall injury importance designators. These designators are shown in Table 52.

The skull, by far, has the highest designator, 42. The neck is next with 25, and the face follows with 20. Eye (6) and cervical (7) together (13) do not equal either of the other designators.

TABLE 51. ACCIDENT INJURY SUMMARY FOR V/STOL AIRCRAFT (JAN. 1969 - MAR. 1978)

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVIC- CAL (5)	TOTAL (1-5)	TOTAL INJURIES		SEATING POSITION TOTALS			
									COCKPIT	CREW/PSGR./UNIK.		
							FATAL	NON- FATAL	FATAL	NON- FATAL	FATAL	NON- FATAL
1969												
1970												
1971	2					2	1		1			
1972												
1973												
1974	3			1	1	5	2		1		1	
1975	1			1	1	3	2		2			
1976		3		2		5		2		2		
1977	1	1	3	2		7	1	2	1	2		
1978												
TOTAL	7	4	3	6	2	22	6	4	5	4	1	0
COMBINED TOTALS							10		9			
									10			

TABLE 52. INJURY DISTRIBUTION BY AIRCRAFT TYPE

Aircraft	Total Injuries	Percentage of Total Injuries				
		Skull	Face	Eye	Neck	Cervical
Attack	265	32	23	8	25	12
Cargo	67	57	25	3	9	6
Fighter	149	33	23	6	33	5
Helicopter	281	44	32	7	12	5
Patrol	60	38	7	3	49	3
Search	31	52	13	3	22	10
Trainer	86	51	17	5	22	5
V/STOL	22	32	18	14	27	9
TOTAL (*)		339	158	49	199	55
Designator		42	20	6	25	7

The designator rankings are supportive of the totals reflected in the head and neck injury summary for the 1969 - 1978 period shown in Table 53. The highest designator (42) accounts for the most injuries of the 1,038 total, the skull with 430 injuries. Neck (25) and face (20) designators account for a total of 476 injuries, leaving only 132 for cervical (7) and eye (6).

The designator can be used in several ways, but here only to prioritize discussion and recommendations.

3.3.1 Protection Considerations

The military crewmen's helmets afford some degree of protection for all but one of the regions under study, i.e., eyes. The skull is completely enclosed; the peripheral extent of the face is partly protected; the upper rear and the sides of the neck are partly protected; and the upper cervical vertebra receives the same protection as the neck rear. The eyes are exposed except for visor attachments.

**TABLE 53. HEAD AND NECK INJURY SUMMARY FOR PERIOD
JAN. 1969 - MAR. 1978**

YEAR	SKULL (1)	FACE (2)	EYE (3)	NECK (4)	CERVI- CAL (5)	TOTAL (1-5)
1969	88	66	22	53	6	235
1970	84	51	7	34	13	189
1971	33	32	2	20	12	99
1972	56	18	6	18	7	105
1973	40	17	7	18	8	90
1974	27	18	3	24	9	81
1975	25	13	2	14	4	58
1976	30	16	1	13	4	64
1977	33	12	10	30	7	92
1978	14	5	2	4	0	25
TOTAL	430	248	62	228	70	1038

DESIG- NATOR	42	20	6	25	7
-----------------	----	----	---	----	---

The skull, which receives the most protection from the helmet, receives the most injuries as shown in Table 53. The face with a designator of 20, the eyes with a 6, and the cervical vertebra with a 7 receive comparatively minor protection, yet they sustain the least injuries - a total of 380 in the data used. Together they account for 50 less injuries than the skull, which has a designator of 42.

The potentiality of the helmet for receiving localized impact and then redistributing the impact to other regions must be considered. The neck and vertebra would probably be most involved in secondary injuries from skull helmet primary impacts. Configuration design and weight of the helmet also plays an impact role in helmet impact distribution.

3.3.2 Directional Considerations

Table 54 provides a total distribution of the position data used in this study. Nearly 46% of the data accounts for fatalities (349 of 765). Cockpit fatalities (194) account for 25% of the position data. There were 387 cockpit injuries involved, 51% of the total 765.

The greatest majority of seats in cockpits face forward, so occupants in most of the accidents used to provide the cockpit data must have been facing forward on initial impact. The fact that the face and eyes sustain such lesser injuries in this environment must mean that forward body rotation occurs and places the skull in the primary impact position. Forces are concentrated first on the frontal and parietal regions of the skull and then transferred to the neck and vertebra. The helmet, while initially acting to attenuate the force, would also serve to maintain a direct downward transfer to the neck and vertebra.

TABLE 54. INJURY POSITION SUMMARY FOR
PERIOD JAN. 1969 - MAR. 1978

TOTAL INJURIES		SEATING POSITION TOTALS			
		COCKPIT		CREW/PSGR./UNK.	
FATAL	NON-FATAL	FATAL	NON-FATAL	FATAL	NON-FATAL
72	111	40	51	32	60
77	61	32	23	45	38
23	49	12	20	11	29
46	36	25	16	21	20
28	42	22	22	6	20
26	29	15	17	11	12
16	22	11	12	5	10
20	22	13	14	7	8
33	35	17	15	16	20
8	9	7	3	1	6
349	416	194	193	155	223
765		387		378	
		765			

On the basis of data analyzed in this program, the primary direction of force initiation and interaction on the skull, face, eyes, neck, and vertebra is believed to be centered on the frontal and parietal regions of the skull.

4.0 INJURY PROFILES

To further support the directional determination established in Section 3.0, the following was accomplished:

- All fatal skull, face, eye, neck, and cervical injuries were tabulated by aircraft model and then combined to obtain type profiles.
- Autopsy comments taken from hard copy of MOR were scored on a drawing to obtain visual correlation with the type profiles.

The number of MOR reviewed (37) was insufficient for complete type profiling in some cases (patrol, search, and V/STOL aircraft) but still supportive of overall trends. The MOR information was adequate for the attack, fighter, trainer, and rotary-wing aircraft profiles.

Professional assistance in developing the injury profiles presented herein was provided by Dr. Brian D. Blackbourne, M.D., Deputy Chief Medical Examiner, Department of Human Resources, Government of the District of Columbia, Washington, D.C.

4.1 AIRCRAFT TYPE FATAL INJURY PROFILES

4.1.1 Attack Aircraft

Table 55 shows the result of tabulating 78 injuries for attack aircraft. The skull sustained the majority (46 of 78); the neck (16) and cervical vertebra (13) combined received 24. The face accounted for only 3 and the eyes none. Considering the totals, decapitation and fractures have an apparent interrelationship between skull and neck.

The nature and severity of the dominant diagnoses (compound/comminuted, decapitation, and avulsion) are also illustrated in Figure 1 which is based on information from 9 MOR cases. The

TABLE 55. ATTACK AIRCRAFT INJURIES

Diagnosis	Skull	Face	Eye	Neck	Cervical	Total
Hemorrhage	2					2
Compound	5			1		6
Compound Comminuted	11	1				12
Decapitation	7			10		17
Evisceration	1					1
Fracture, Simple	4			3	3	10
Avulsion	7					7
Comminuted	1					1
Crushing	1					1
Depressed	1					1
Laceration	4					4
Transection	1				10	11
Contusion	1	2		1		4
Dislocation				1		1
TOTAL	46	3		16	13	78

upper head and neck injuries are typically fatal or critical in severity, while the facial injuries would be considered severe but not life threatening for the most part.

4.1.2 Fighter Aircraft

Of 52 fatal injuries used for fighter aircraft, the skull received 36 and the neck (11) and cervical vertebra (5) combined received 16 as shown in Table 56. No injuries to the face and eyes were included in the printout. Avulsion and decapitation dominate the diagnoses on a part and total basis, ample evidence of the severity of the fighter aircraft crash environment.

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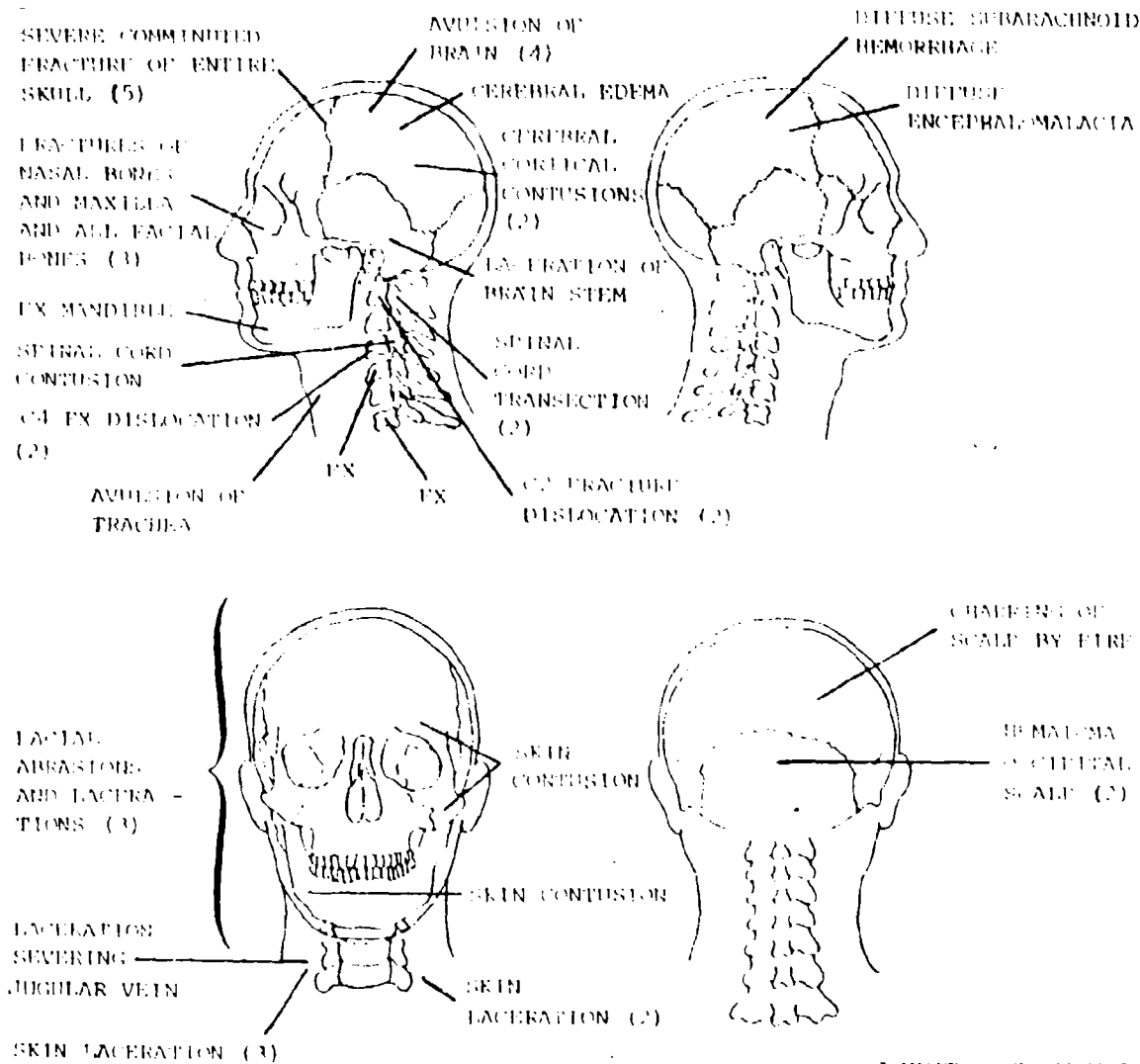


Figure 1. Attack Aircraft Injury Profile.

TABLE 56. FIGHTER AIRCRAFT INJURIES

Diagnosis	Skull	Face	Eye	Neck	Cervical	Total
Avulsion	6					6
Depressed	1					1
Crushing	3					3
Comminuted	2					2
Compound	2					2
Compound Comminuted	3					3
Decapitation	6			9		15
Hemorrhage	5					5
Laceration	3					3
Asphyxia/Strangulation				1		1
Contusion	2					2
Hematoma	1					1
Fracture, Simple	1			1		1
Compression					1	1
Rupture	1					1
Dislocation					1	1
Transection					3	3
TOTAL	36			11	5	52

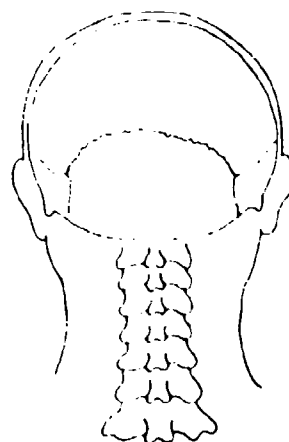
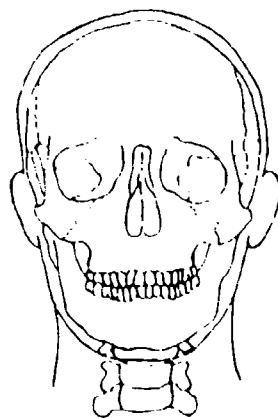
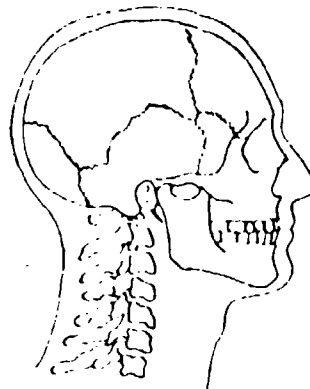
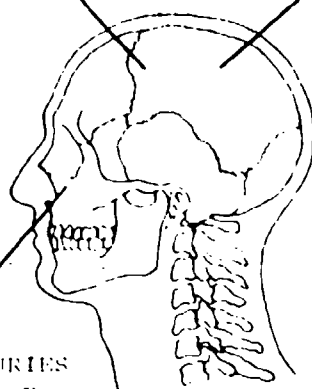
Only two MOR cases were used for the profile shown in Figure 2, yet even this limited input supports the dominant skull injury trend.

90507607

SEVERE COMMINUTED
FRACTURE OF SKULL
(2)

AVULSION OF
BRAIN (2)

EXTENSIVE INJURIES
AND FRACTURES OF
FACIAL BONES (2)



INPUT: 2 CASES

Figure 2. Fighter Aircraft Injury Profile.

4.1.3 Trainer Aircraft

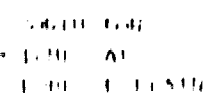
The many varied configurations of trainer aircraft (T-1, T-2, T-2B, T-33, T-34, and T-39) on which the source data were based did not offset or alter the injury trend already established. Table 47 clearly shows the dominance of skull injuries on a 3-to-1 ratio for neck injuries. Of note, no face or eye injuries were reported, the latter the least protection afforded by the helmet. Penetration dominated the total data, and fractures, transections, and avulsion share next equal importance.

TABLE 47. TRAINER AIRCRAFT INJURIES

Injury	Skull	Face	Eye	Neck	Penetration	Total
Compound/Compound	5					5
Decapitation	4			6		10
Penetration	3					3
Edema	1					1
Transection	1			2		3
Compound	1					1
Fracture, simple	4			1		5
Amputation	1					1
Avulsion	4					4
Cushing	2					2
Compound	3			1		4
Compound	1					1
TOTAL	40			10		50

Figure 4, based on 200 cases, does show face, eye, and neck injuries which could be survivable. In fact, most of the injuries shown would be considered minor, moderate, or severe (not

0
1
2
3
4
5
6
7
8



44

life threatening) by themselves, but when identified as additional injuries involving the fatal skull primary injuries, the data again points to the primary directional influence on the skull.

4.1.4 Helicopters

As Table 58 shows, the skull is by far the most affected injury region for helicopters, accounting for 35 of 42 injuries. The neck (4) and face (3) account for the remainder (7).

TABLE 58. HELICOPTER INJURIES						
Diagnosis	Skull	Face	Eye	Neck	Cervical	Total
Compound Comminuted	3	1				4
Avulsion	10					10
Comminuted	2	1				3
Compound	7					7
Crushing	3			1		4
Decapitation	4			2		6
Fracture, Simple	1					1
Abrasion		1				1
Transection	2			1		3
Depressed	2					2
Hemorrhage	1					1
TOTAL	35	3		4		42

The helicopter profile in Figure 4 is based on 4 MORT cases, only 2 of the injuries shown would be considered singularly fatal, i.e., severe open fractures of the face and skull and avulsion of the brain. The others could be categorized as severe (life threatening, survival probable), severe (not life threatening), moderate, and minor. The overriding influence of the primary skull injury is quite evident.

20
 21
 22
 23
 24
 25
 26
 27



11.

4.1.5 Search Aircraft

As shown in Table 59, decapitation is singularly credited to the neck for search aircraft, and it and avulsion dominate the total data reported. The skull receives 10 of the 19 injuries reported, and the neck (5) and cervical (3) together (8) account for all but one injury which was sustained by the face.

TABLE 59. SEARCH AIRCRAFT INJURIES

Diagnosis	Skull	Face	Eye	Neck	Cervical	Total
Decapitation				4		4
Avulsion	3					3
Compound	1					1
Depressed	2					2
Laceration	2					2
Comminuted		1				1
Fracture, Simple				1	1	2
Hematoma	1					1
Hemorrhage	1					1
Dislocation					1	1
Transaction					1	1
TOTAL	10	1		5	3	19

Figure 5 (based on 5 MOR cases) supports the dominance of fatal skull injuries, but also shows several injuries to the face which are singularly survivable. Here again is demonstrated the primary severity of impacts on the frontal region of the skull and interrelated effects on the neck/cervical region.

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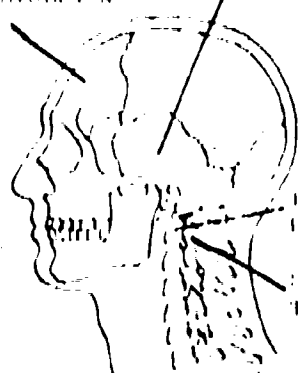
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COMMUNITY FRACTURES
WITH PARTIAL AVULSION
OF BONES (2)

CONTUSION HEMORRHAGE
OF BRAIN STEM

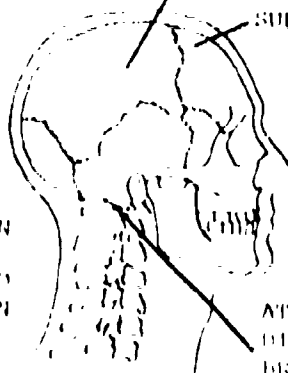
AVULSION OF SPAIN (2)

SUBDURAL HEMATOMA



EXC
DEFORMATION

SPINAL CORD
TRANSECTION

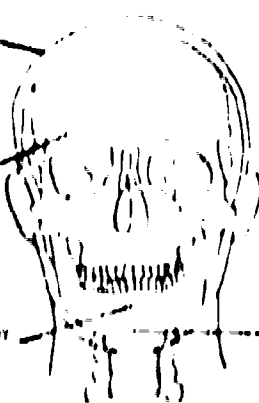


ATLANTO-OCIPITAL
DISLOCATION WITH
BRAIN STEM
TRANSECTION

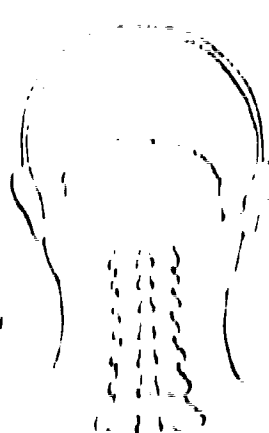
SCALE SEVERELY
BURIED (2)

FRACTURE OF ALBOW
RIGHT ELBOW

FRACTURE OF ELBOW
LOWER LIMB



EXC
OF CHIN



EXC
OF CHIN

Figure 5. Trench Warfare Injury Profile.

4.1.6 Patrol Aircraft

Only limited data were available for patrol aircraft, but they continue to demonstrate the skull and neck/cervical region interrelationship. Neck and skull dominance is shown in Table 60.

TABLE 60. PATROL AIRCRAFT INJURIES						
Diagnosis	Skull	Face	Eye	Neck	Cervical	Total
Compound Comminuted	2					2
Fracture, Simple	1				1	2
Hemorrhage	1					1
Decapitation				6		6
TOTAL	4			6	1	11

Figure 6 is based on only 2 MOR cases; all injuries shown would be fatal or critical (survival uncertain).

4.1.7 V/STOL Aircraft

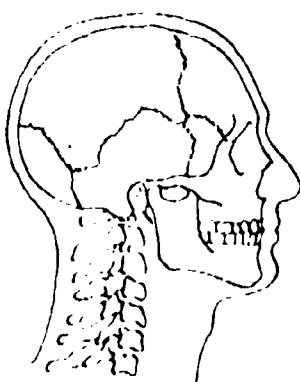
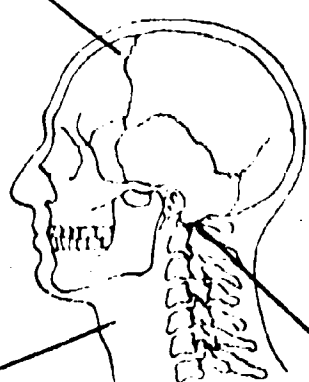
As Table 61 shows for V/STOL aircraft, injuries are again grouped under skull and neck/cervical. Fractures dominate the total 11 injuries reported, and also show prevalence in the profile, Figure 7, which is based on 4 MOR cases.

For the V/STOL aircraft, there is some departure from the trend consistent in data on other aircraft. A general fractionation of the head from various directions seems evident, as opposed to the skull-to-neck/cervical relationship. Also, most of the injuries would be survivable if treated on a singular basis.

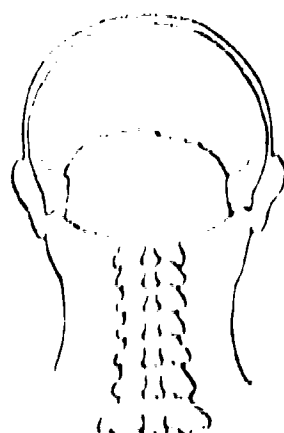
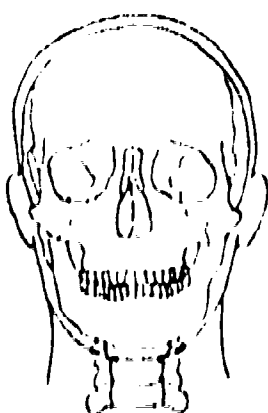
20507506

SEVERE COMMINUTED FRACTURES
OF SKULL WITH AVULSION OF
BRAIN (PARTIAL DECAPITATION)

AVULSION OF
LARYNX



COMPLETE DECAPITATION
WITH LOSS OF CERVICAL
VERTEBRA AND HEAD



INPUT 7 CASES

Figure 6. Patrol Aircraft Injury Profile.

TABLE 61. V/STOL AIRCRAFT INJURIES

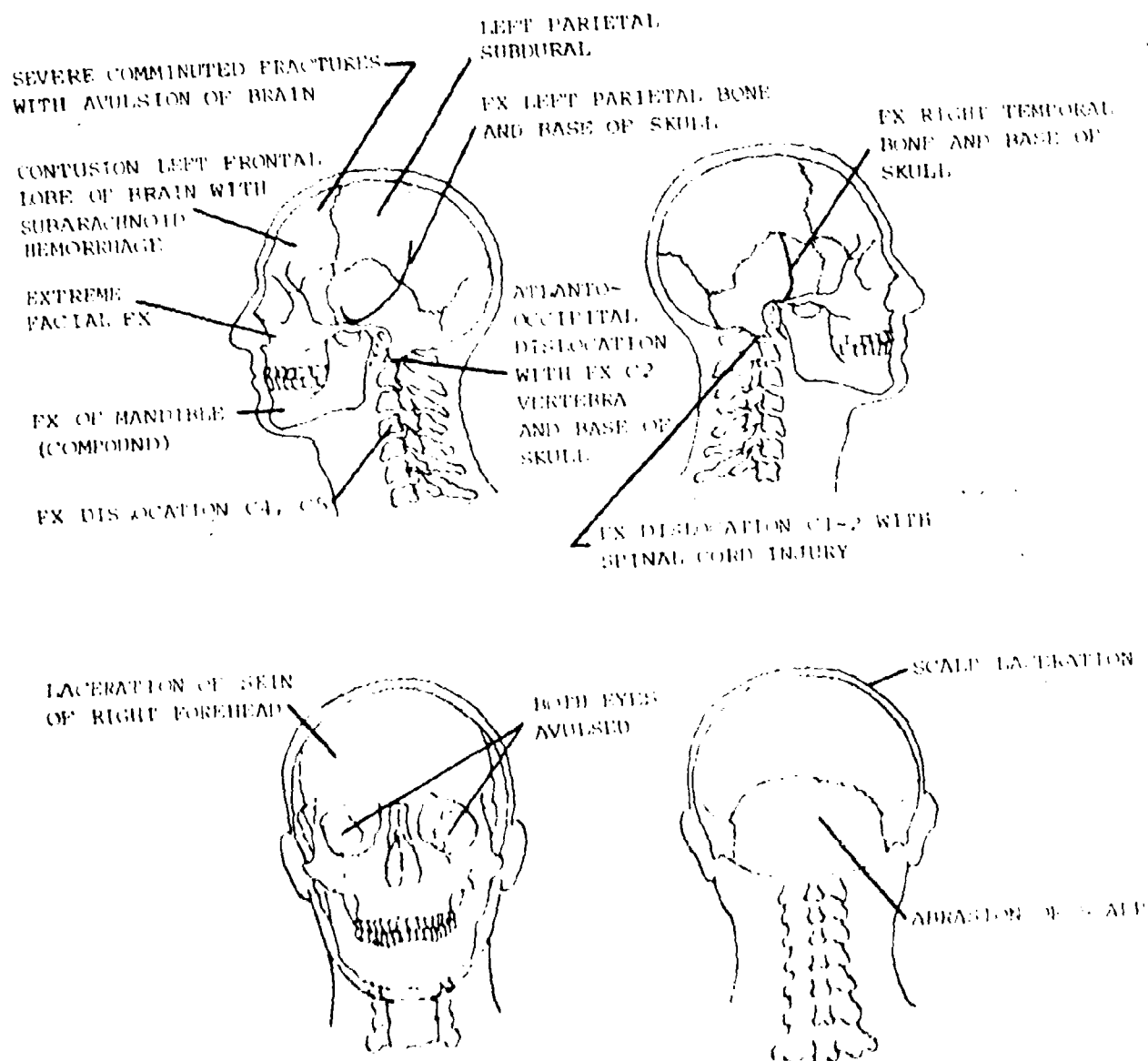
Diagnosis	Skull	Face	Eye	Neck	Cervical	Total
Comminuted	1					1
Fracture, Simple					1	1
Compound	1					1
Contusion	1					1
Perforation				1		1
Dislocation					1	1
Decapitation	1			1		2
Compound Comminuted	3					3
TOTAL	7			2	2	11

4.2 ANALYSIS AND DISCUSSION

This discussion is made without consideration of injuries which were sustained by parts of the body other than the skull, face, eye, neck, and cervical vertebra; the scope of the program limited study to the parts named. Severe injuries to the head and neck regions, however, do limit the performance of other body parts to the extent that their consideration would be of secondary importance.

The data presented in this section does not in all cases complement each other. For example, the total-injury-by-aircraft model printout identified no face or eye injuries for the AV-8A aircraft as listed in Table 61, yet face and eye injuries were identified in the autopsy results reviewed in the 4 MOR cases illustrated in Figure 7. This was found in only a few cases, however, and the rate of incidence is not sufficient to influence overall statistics and trends.

90507009



INPUT: 1 CASE

FIGURE 7. V/STOL AIRCRAFT INJURY PROFILE.

Considering all of the injury dominance discussed heretofore, and knowing the injury areal effects, the following discussion seeks to impart rationale for further research to decrease injuries to the head and neck regions.

The data presented in this section are from fatal accident injuries which obviously exceed human tolerance to impact where skull fractionation, avulsion, decapitation, etc., occur and dominate. To remove or reverse this dominance in the aircraft accident environment cannot be accomplished on an overall basis. Instead, the problem (3) must be technically addressed on an individual aircraft model or type basis. Where there is a prevailing directional influence which can be identified on an overall basis, however, and where direct causal relationship can be established between the elements affected in the impact chain, such as the helmet, head, and neck, then it is possible to identify and concentrate on a specific objective which will benefit and upgrade survivability in all aircraft models and types.

The helmet is the only non-human device among the elements of the helmet, head, and neck chain involved, and it has been the subject of extensive developmental research. Existent configurations have evolved on the basis of accident studying and material refinement made to obtain the most safety and yet satisfy and permit operational functions. However, knowing the certainty of more fatalities and disabling injuries, which can be assumed on a statistical basis, then even more research and refinement appears as a natural course of action.

The primary cause of the dominance of skull and neck/cervical injuries is due to impacts received as the upper body is undergoing severe decelerative force while restrained in a relatively upright position, and the head, influenced by the weight of the helmet, uncontrollably undergoes forward and downward flexion. This places

the frontal and parietal parts of the skull in position for secondary impact with any object in front of the head; primary impact will be on the portion of the helmet covering these skull parts. As the impact chain activates and functions, the forces encountered by the helmet/head are transferred to the neck which ultimately must serve to diminish some of the head impact and accept near final force concentration.

If an interruption in the load transfer can be accomplished, or if the initial impact force can be ameliorated, then the skull and neck will benefit. Future research then should incorporate these basic objectives:

- Investigate mechanical means in the helmet structure which will facilitate load interruption and/or attenuation.
- Investigate lightweight energy-attenuating devices and materials which can become a part of the helmet exterior.

5.0 MOR REPORTING SYSTEM

The Navy MOR system provides a very extensive and completely detailed account of aircraft accidents. It provides information on:

- Aircraft and personnel involved, and includes a narrative of the accident.
- Injuries incurred.
- Psychophysiological and environmental factors.
- Demographic and training proficiency data.
- Personal, survival, and escape equipment usage.
- Escape and egress information on each person.
- Ejection or bailout information, including helmet, restraint system, and seat usage.
- Survival and rescue information.
- Flight surgeon's comments, analyses, and recommendations, including autopsy findings if appropriate.

Through analysis and using an in-depth EDP procedure, the accident information from the MOB is computerized and available for use by Naval Safety Center personnel.

The information available in hard copy and from the data bank are more than adequate for a study of this nature. The system's capability to provide both event and injury data is considered excellent.

The only information not found in the MOR system is engineering data which could be used for hardware-related medical determinations. Examples would be drawings and/or photographs of areas and specific structure/components which caused or contributed to injuries. There was some inclusion of this type of data in the older MOR reviewed.

In each MOR, the flight surgeon is asked to make comments, analyses, and recommendations on the accident being reported. The recommendations made for improving safety and procedures seemed sincere, reasonable, and conscientious in most of the MOR hard copies reviewed. It was beyond the scope of this effort to determine the effectiveness of the recommendations in "getting things done." A study devoted to this determination would be of interest if based on a period of long enough duration to yield representative results.

6.0 INJURY COSTS

The costs of injuries derived from accidents is now an important element in determining information to support decisions for new designs, making procurements, writing standards and specifications, etc. Such costs are also factors in making cost/benefit determinations, and are considered essential for the rule making process.

The military departments have assigned dollar loss values based on grade, flight status, crewmanship, etc. In comparing these values with values used by civil departments, it was found that the military values are much lower than civil values for persons who have no professional or technical training.

To illustrate the above, discussion on use of the Abbreviated Injury Scale (AIS) used by the National Highway Traffic Safety Administration (NHTSA) for motor vehicle accidents is presented.

The AIS was first published in 1971 by a joint Committee of the American Medical Association, the Society of Automotive Engineers (SAE), and the American Association of Automotive Medicine (AAAM). The scale was devised in response to a research need for a consistent scale for collecting and analyzing injury severity data and, specifically, for use by multidisciplinary accident investigation teams, which were being set up by the National Highway Traffic Safety Administration. Since that time, AIS has gained acceptance in accident investigation research, and it is likely that its use will increase in the future.

The AIS has undergone several revisions since its inception. The most recent revision of AIS was done by the Subcommittee on Injury Scaling of the SAE. The scale, as it now stands, is as follows:

AIS CodeCategory

1	Minor
2	Moderate
3	Severe (not life threatening)
4	Severe (life threatening, survival probable)
5	Critical (survival uncertain)
6	Maximum severity (currently untreatable)

Table 62 presents the average cost per fatality and injury by AIS level.

TABLE 62. SOCIETAL COSTS, SUMMARY, 1975 (DOLLARS)

Cost Component	Injury Severity (AIS)						PDO
	6	5	4	3	2	1	
Production/Consumption:							
Market	211,820*	126,650*	55,550*	1,645	865	65	-
Home, family and community	63,545*	37,995*	16,660*	425	310	20	-
Medical:							
Hospital	275	5,750	2,250	1,095	450	45	-
Physician and other	160	5,520	2,160	525	165	55	-
Coroner-medical examiner	130	-	-	-	-	-	-
Rehabilitation	-	6,075	3,040	-	-	-	-
Funeral	925*	-	-	-	-	-	-
Legal and Court	2,190	1,645	1,090	770	150	140	7
Insurance Administration	295	295	285	240	220	52	30
Accident Investigation	80	80	70	45	35	28	6
Losses to Others	3,685	4,180	1,830	260	130	32	-
Vehicle Damage	3,990	3,990	3,960	2,920	1,865	1,595	315
Traffic Delay	80	60	60	160	160	160	160
TOTAL	287,175	192,240	86,955	8,085	4,350	2,190	520

*Seven percent discount rate.

Using the \$287,175 loss-of-life value (AIS 6) in Table 62, the costs of fatalities used in this analysis would be as shown in Table 63.

TABLE 63. SOCIETAL COSTS OF NAVY FATALITIES
BASED ON AIS 6 (1969 - 1978)

<u>Year</u>	<u>Number Fatalities</u>	<u>Societal Costs</u>
1969	72	\$ 20,676,600
1970	77	22,112,475
1971	23	6,605,025
1972	46	13,210,050
1973	28	8,040,900
1974	26	7,466,550
1975	16	4,594,800
1976	20	5,743,500
1977	33	9,476,775
1978	8	2,297,400
TOTAL	349	\$100,224,075

If comparable Navy injury loss values for AIS 1 through 5 were computed for the 416 non-fatal injuries reported, the total societal costs for the 10-year period would be appreciably greater.

It is understood that societal costs for motor vehicle accidents can not reflect the worth of training, medical, and other factors in a Naval injury. If values similar to the AIS levels were formulated, however, they would prove to be a valuable command management tool in training and other staff functions.

7.0 CONCLUSIONS

On the basis of the study reported herein, the following conclusions are made:

1. The principle directional influence on skull, face, eye, neck, and cervical injuries is centered in the frontal and parietal regions of the skull.
2. Emphasis should be placed on personal safety and survival equipment research in high-performance aircraft.
3. Specific aircraft models and types can be identified which warrant further engineering and/or analytical research.
4. The flight surgeon's recommendations (made over a long-term period) for improving aircraft safety and search and rescue operations should be assessed for effectiveness.
5. A simplistic cost value for fatalities and injuries, similar to the NHTSA AIS system, would be of considerable value to Naval safety engineering and management and in conducting studies of the type reported herein.
6. Navy MOR and the Naval Safety Center data bank are efficient and responsive media for establishing and supporting research objectives; availability of injury-related engineering information would further enhance research effort.

8.0 RECOMMENDATIONS

The following recommendations are made:

1. Further research should be devoted to the role the helmet plays in:
 - Preventing injuries
 - Causing injuries
 - Distributing impact force received on the frontal and parietal regions of the skull.
2. Cost benefit analysis should be made to determine the extent to which life support systems should be refined in high performance aircraft, if not already accomplished. Trade-off parameters should include points at which refinement is directed to personal safety and survival equipment.
3. The causation for dominance anomalies of injuries in certain aircraft models/types should be determined, if not already known. Examples are:
 - High cockpit fatality rates for the S-2 and S-3 (14 of 22 position data)
 - A 270% increase in injuries and a 200% increase in fatalities in helicopters from 1976 to 1977
 - High neck injury rates and fatality rates in patrol and search aircraft.
4. A study be made of action taken on recommendations made by flight surgeons in accident reports to determine the benefits derived from implementation and the results of not implementing recommendations.
5. A costing system based on recent dollar values be developed for injuries and fatalities.
6. Total fatality and injury profiles by aircraft models and types be developed from data in the Safety Center data bank. Such profiles could be used in programs to emphasize training proficiency attainment and accident prevention. "Shock graphics" are considered effective in both industry and government.